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Origins of Sockeye Salmon Caught within the Harbor Point to Stroganof Point Reach of the Alaska Peninsula Management Area, 8-21 July, 1990

by

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State of Alaska Walter J. Hickel, Governor

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ORIGINS OF SOCKEYE SALMON CAUGHT WITHIN THE HARBOR POINT TO STROGONOF POINT REACH OF THE ALASKA PENINSULA MANAGEMENT AREA, 8-21 JULY, 1990.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

Stock composition of the Alaska Peninsula Management Area sockeye salmon *Oncorhynchus nerka* catch from Harbor Point to Strogonof Point during 8-21 July 1990 was estimated using scale pattern analysis. This catch represented approximately 50% of the total 1990 sockeye harvest within this area. Age-2.2 and -2.3 scale patterns were used with standards derived from North Peninsula Bear River escapement and Nelson Lagoon catch samples; Bristol Bay standards were obtained from terminal catch district samples.

Models derived for classifying age-specific commercial catch scales collected from fish of unknown origin had mean correct classifications of 77% for age-2.2 and 74% for age-2.3. The age-2.3 model was evaluated for stability using Monte Carlo simulations. Estimated stock composition of the Harbor Point to Cape Seniavin area catch, inclusive of all age classes, was 48% Nelson River, 42% Bristol Bay, and 10% Bear River. Estimated stock composition of the Cape Seniavin to Strogonof Point area catch was 78% Bristol Bay, 11% Bear River, and 11% Nelson River fish. Abundance of Bristol Bay sockeye salmon in the North Peninsula Harbor Point to Strogonof Point area, during July, may be a function of Bristol Bay run strength.

KEY WORDS: Sockeye salmon, *Oncorhynchus nerka*, stock separation, scale pattern analysis, North Peninsula

INTRODUCTION

Alaskan commercial salmon fisheries are managed for attaining annual fixed, system-specific escapement goals which ensure future harvestable surplus and stock perpetuation. Escapement goals and preseason run forecasts are based on run reconstructions using catch and escapement statistics. To reconstruct runs postseason, a time series of accurate age and stock composition estimates from catches and escapements are required. Scale samples for completing this task are collected annually by the Alaska Department of Fish and Game.

Sockeye salmon *Oncorhynchus nerka* fisheries of the Alaska Peninsula are managed for local stock harvests with several Board of Fisheries approved exceptions ADF&G (1991). Management of the remaining districts and areas is accomplished realizing that non-local stocks are caught to a limited extent.

The Alaska Peninsula commercial salmon management area is separated into two distinct units: (1) South Peninsula, inclusive of coastal waters extending from Kupreanof Point to Scotch Cap; and (2) North Peninsula, incorporating coastal waters west from Cape Menshikof to Cape Sarichef, which is subdivided into the Northwestern and Northern Districts (Figure 1). The latter district encompasses Harbor Point to Strogonof Point (Figure 2). In the Herendeen-Moller Bay Section (including Harbor Point) seine and gillnet gear are legal. Seine and drift gillnet gear are allowed in the Bear River Section but gillnet gear is predominant. Within the Three Hills Section only drift gillnet gear is legal, whereas in the Ilnik Section both drift and set gillnet gear are permitted. A majority of effort along the outer beach of the Ilnik Section is drift gillnet (Murphy 1991). The Northern District includes two major sockeye systems (> 100,000 fish escapements), Bear and Nelson Rivers, and four minor systems (usually < 100,000 fish): Sandy, Ilnik, Meshik, and Cinder Rivers.

Since 1985, ADF&G has collected catch and escapement age data for performing run reconstruction to quantify returns from local spawning stocks. This information, coupled with data collected from adjoining management areas provides for estimating local and non-local contributions to Northern District fisheries. Geiger (1989), using scale pattern analysis (SPA), estimated that between 5 and 21 July 1987, 1988, and 1989 North Peninsula stocks contributed 66%, 55%, and 64% of the sockeye salmon harvested within the Cape Seniavin to Strogonof Point area; Bristol Bay bound sockeye (Ugashik Stock only) contributed the balance. However, Geiger stated that stock proportions could fluctuate interannually because of variation in migration patterns and fleet dynamics.

During 1990, a total of 2.4 million sockeye salmon were commercially harvested in the North Peninsula area with 0.88 million caught in the Harbor Point to Cape Seniavin area (Table 1) and 0.94 million caught within the Cape Seniavin to Strogonof Point area (Table 2). Approximately 50% (881,943) of the combined total catch for both areas occurred during 8-21 July, with 13% of this catch occurring within the Harbor Point to Cape Seniavin area and 81% in the Cape Seniavin to Strogonof Point area.

The goal of this investigation is to estimate stock composition of commercial sockeye catches within the Harbor Point to Strogonof Point area of the North Peninsula for the 8-21 July 1990 period.

METHODS

Estimation of Contributing Stocks

Timing of North Peninsula and Bristol Bay (Ugashik, Egegik, and Naknek-Kvichak) stocks were used to identify potential contributors for Harbor Point to Cape Seniavin and Cape Seniavin to Strogonof Point fisheries catch. Weekly terminal commercial catches from Ugashik (UG), Egegik (EG), Naknek-Kvichak (NK) Districts, and Nelson River (NR) as well as escapement counts from Bear River were lagged back in time to approximate presence within the two areas (Appendix A.1-A.4). The geographical midpoint of each fishing area, and a 48-km (30 mi) per day travel rate were used in the calculations (Quinn 1988):

Harbor Point to Cape Seniavin Reach:

North Peninsula stocks

Bear River:	0 d prior
Nelson Lagoon:	1 d prior

Bristol Bay stocks

Ugashik District:	5 d prior
Egegik District:	6 d prior
Naknek-Kvichak District:	8 d prior

Cape Seniavin to Strogonof Point Reach:

North Peninsula stocks

Bear River:	2 d prior
Nelson Lagoon:	3 d prior

Bristol Bay stocks

Ugashik District:	3 d prior
Egegik District:	4 d prior
Naknek-Kvichak District:	6 d prior

Catch Numbers, Escapement Enumeration, and Age Composition

Commercial catch and escapement numbers for the North Peninsula were obtained from ADF&G (1991) and for Bristol Bay from ADF&G (1990). Catch numbers were compiled using individual harvest receipts (fish tickets), whereas escapement numbers were derived from weir, tower, and aerial survey counts. Catch and escapement scale sampling design, intensity, and procedures for the North Peninsula are provided in Murphy (1991) and for Bristol Bay in Cross and Stratton (1988). Catch and escapement age composition estimates were derived using scale samples and obtained from Murphy (1991) for the North Peninsula and for Bristol Bay by Beverly Cross (Alaska Department of Fish and Game, Anchorage, personal communication). All ages herein are reported in European notation with the integer left of the decimal point referring to freshwater age, and to the right, marine age (Koo 1962). Total age is the sum of freshwater and marine ages plus one.

Scale Measurement and Stock Composition Estimation

Maximum sample sizes of 200 scales were selected for establishing standards for known stocks and also for selecting unknown mixed stock fishery scales (Cook 1982). Standards for North Peninsula stocks were developed from Nelson River terminal commercial catch and Bear River weir escapement scales. Bristol Bay stock standards were constructed from terminal catch scale samples obtained from the Ugashik, Egegik, and Naknek-Kvichak Districts. For standards derived from commercial catch, scales were chosen proportional to the time periods with the highest back-calculated catches (refer to Appendix A.1-A.4). Bear River standard scales were chosen from escapement samples collected separately for the early component (BRE; 24 June through 21 July) and late component (BRL; 29 July through 18 August); early and late run timing was provided by James McCullough (ADF&G, Kodiak, personal communication). Unknown samples were selected by obtaining the first 200 scales available for a particular age class. The age classes selected for SPA were based on Harbor Point and Strogonof Point mixed stock age composition estimates, of which a majority (>75%) were age-2.2 and -2.3 fish (Tables 3-4). These age classes in composite, represented greater than 50% of the age composition for Bear and Nelson Rivers escapements, and Bristol Bay area terminal catches (Tables 5-7). Scale samples were not collected from North Peninsula minor systems, except for Ilnik River, which had few age-2.2 or -2.3 fish (<28% combined). Escapement estimates for North Peninsula systems in aggregate were 958,800 sockeye salmon, of which minor systems comprised 17.9% (Appendix B.1).

Scale-measurement data were collected using the Biosonics optical pattern recognition system (OPRS), which integrates a compound microscope, ocular lens, frame grabber, digitizing tablet, and microcomputer. Scale-data collection procedures consisted of (1) establishing a horizontal reference line through the reticulated region; (2) identifying the center of the scale focus or starting point; (3) measuring incremental distances from scale focus to each circuli within the first and second freshwater annular zones, off of an axis perpendicular to the reference line (Narver 1963); and (4) saving measured data to a file. All scale measurements were specific to age class and collected at about 200X magnification. Scales with poorly defined images and those collected from a non-preferred region (Clutter and Whitesel 1956) were not measured.

Raw measurements were transformed into individual variable format using a BASIC program, REFORM1 (Written by Larry Greer, ADF&G, Kodiak, AK). Variables constructed were circuli counts (CC) and incremental circuli distances (ID) which start at the scale focus and end with the last circulus of the second freshwater annulus. These variables represent a portion of the freshwater growth for each stock or stock complex (group of stocks combined), regardless of annular zone. Measurements specific to annular zone were not collected. The maximum number of variables available for model development was limited to the fewest number of circuli counted on any single scale among stock standards; e.g., if a stock had one scale with only 10 circuli, then the maximum number of potential variables for that stock would be 11, 10 incremental distances and one circuli count.

The goal of SPA is to develop a model or set of models which accurately identify individuals from known stocks in mixed stock samples. The most widely implemented approach relies upon the linear discriminant function (LDF; Fisher 1936) which was employed for this investigation. Assumptions associated with the LDF are (1) multivariate normality, (2) variance-covariance matrices between stocks are equal, and (3) all probable stocks contributing to mixed stock samples are represented. Evaluating univariate normality was accomplished by screening all variables for each stock using frequency histograms. Tests of the variance-covariance structure were performed using a procedure described by Box (1949). Variables assumed normal in distribution were subjected to a stepwise variable selection procedure (α=0.1) (PROC STEPDISC, SAS Institute, 1987) for identifying variables with large discriminant weight. The accuracy of a model in correctly classifying individuals to stock or group of origin was determined by the "leaving-one-out" approach of Lachenbruch (1967). Models were also developed which had all possible variables included (Davis 1987) and compared to variable-selected models. Choice of a model (variable selected or variable forced) for classifying unknown samples was based on correct classification accuracy (Habbema and Hermans 1977). Stock composition estimates derived for unknown samples were adjusted for misclassification error using the matrix correction approach of Cook and Lord (1978), with 90% confidence coefficients calculated using the variance formula of Pella and Robertson (1979). Confidence coefficients for two stock models were calculated assuming a normal distribution, and for multiple stock models, the chi-square distribution. Variable means between stocks were tested for differences using Hoteling's T^2 test statistic at α=0.05. All discriminant modeling and testing procedures were completed using PROC DISCRIM (SAS Institute 1987).

Age-2.2 Model Development

Initially, a six-stock model was constructed including NR, UG, NK, EG, BRE and BRL stock standards. Approximately 200 scales were measured for BRE, BRL, NR, and NK, whereas 167 were measured from EG and 98 from UG. Overall classification accuracy was 59.6%, with misclassification errors (>12%) occurring within Bristol Bay, and between Bristol Bay and North Peninsula stocks. A four-stock model was constructed with Bristol Bay (UG, NK, and EG combined), NR, BRE and BRL separate. However, when this model was used for classifying unknowns, the BRL stock was estimated as not present, so it was removed and a three-stock model (BRE, NR, and Bristol Bay) used. Classification accuracy (77.0%) and balance within misclassification between stocks improved. A third model was constructed using Ugashik, Naknek-Kvichak, Egegik, with North Peninsula stocks combined into a separate stock complex; classification accuracy decreased (75.7%) compared to the three-stock model. The three-stock model was used to classify both Harbor Point to Cape Seniavin and Cape Seniavin to Strogonof Point unknowns. For commercial fisheries areas with <200 age-2.2 scales, all those available were measured. Stock composition estimates derived for unknowns were corrected for misclassification errors prior to estimating stock proportions in the commercial catch.

Age-2.3 Model Development

A five-stock model was constructed from scales measured from BR escapement (no distinction between early and late runs), NR, UG, NK, and EG commercial catch scale samples. Two hundred scales were measured from each stock, except Naknek-Kvichak which had a sample size of 133. Model performance was poor (45.7% correct classification) with high misclassification between all stocks. Next, a four-stock model UG, NK, and EG separate, with North Peninsula stocks combined was developed; low classification accuracy (49.3%) again surfaced with large misclassification between all stocks. A third model that collapsed both Bristol Bay and North Peninsula stocks had mean classification accuracy of 73.5%. This model was used to classify the age-2.3 unknowns from the Harbor Point to Strogonof Point catch. Unknown sample sizes ranged from 143 to 199 measured scales. Partitioning the estimated North Peninsula age-2.3 stock component to system of origin was accomplished using relative proportions of estimated age-2.2 to age-2.3 fish within Bear and Nelson Rivers escapements and age-2.2 generated stock composition estimates. A similar procedure is reported in Cross and Stratton (1988).

Age-2.3 Model Bias Assessment

Evaluating age-2.3 model bias as a function of true stock proportions was accomplished by a Monte Carlo simulation procedure which randomly selected, with replacement, predefined numbers of North Peninsula and Bristol Bay scale measurements from known scale files. Each scale record selected was conditionally independent. Scale records were read to mixture files and analyzed with the age-2.3 model developed for classifying fisheries unknowns. Files were constructed with known proportions of 1.0:1 (N=200), 0.7:1 (N=168), and 0.2:1 (N=125) Bristol Bay to North Peninsula stocks with 90, 86, and 435 simulations conducted, respectively. The Cook and Lord matrix correction procedure was used for all simulation results. Normality of simulation data was assessed using normal probability plots of residuals. Deviations of mean residual errors from zero of the 0.2 North Peninsula (0.2:1 North Peninsula to Bristol Bay mixture) expected proportion (both uncorrected and corrected) were assessed using t-tests at $\alpha=0.05$.

RESULTS

Stock Separation Models

Age-2.2 Models

Among North Peninsula and Bristol Bay stocks, Bear River early had the fewest number of circuli (12), including both freshwater annular zones, which set the maximum number of variables considered for each stock at 13. A test of homogeneity of variable means for Bear River early and late run components yielded a significant test statistic $P<0.01$, prompting use of BRE and BRL standards for modeling. Screening of variables for each stock found no non-normal traits and all were subjected to stepwise selection. Variables identified as having large discriminant weights were V2, V5-V10, V12 and V13 (Appendix C.1). A three-stock (Bristol Bay, NR, and BRE) all variable forced model performed better (higher mean correct classification) than the variable selected model. Tests of variance-covariance equality yielded significant $P<0.01$ statistics for all models developed.

Correct classification accuracies by stock were Bristol Bay (62.4%), Bear River early (87.5%), and Nelson River (78.7%). Mean classification accuracy for this model was 77.0% (Table 8). Stock composition of age-2.2 sockeye catches for the periods 8-14 July and 15-21 July for Harbor Point to Cape Seniavin and Cape Seniavin to Strogonof Point were estimated using the three-stock all variable forced model (Table 9).

Age-2.3 Models

As was the case for age-2.2 stocks, 13 variables were the maximum available for age-2.3 models, because only 12 circuli were present for the BR stock. No scale pattern differences between samples collected from the early and late Bear River run components were observed, therefore a single age-2.3 standard was constructed. The stepwise selection process identified V4, V5, V7, and V10 through V13 as having the largest discriminant weights. A variable selected, two-stock model with Bristol Bay and North Peninsula stocks combined had classification accuracies of 70.0% Bristol Bay and 71.0% North Peninsula, whereas an all-variable forced model improved classification accuracies to 72.9% and 74.0% for these stock complexes (Table 10). Tests of variance-covariance structure for all models evaluated were significant $P<0.01$. Age-2.3 unknown scale samples from Harbor Point to Cape Seniavin and Cape Seniavin to Strogonof Point collected during 8-14 and 15-21 July were analyzed using the two-stock, variable forced model (Table 11).

Age-2.3 model simulations for the uncorrected estimates appear to be biased towards North Peninsula stocks; however, the Cook and Lord matrix correction procedure reduced the bias to a minimum (Figure 3). Residual errors for the 1:0.25 Bristol Bay to North Peninsula proportion were approximately normal. A hypothesis test of whether the mean residual error for the uncorrected proportions was statistically different from zero was significant (P<0.01), whereas a test for the corrected proportions mean residual error was not significant (P=0.454).

Estimated Catch Composition

Harbor Point to Cape Seniavin

Total sockeye catch during 8-14 July was 57,713 fish: 11.4% were age-2.2 and 84.5% age-2.3. For the age-2.2 component 67.3% were estimated to be of Bristol Bay origin, 22.8% of Nelson River origin, and 9.9% Bear River origin (Figure 4). Age-2.3 sockeye salmon were estimated to be 29.1% Bristol Bay fish, 64.5% Nelson River, and 6.4% Bear River (Figure 5).

Within the period 15-21 July, 60,444 sockeye salmon were caught, including an estimated 25.4% age-2.2, and 68.5% age-2.3 fish (Table 3). Stock composition estimates for age-2.2 fish were 59.6% from Bristol Bay, 20.2% Nelson River, and 20.2% from Bear River (Figure 4). The age-2.3 catch was 45.9% Bristol Bay, 43.8% Nelson River, and 10.3% Bear River fish (Figure 5).

Estimated sockeye harvests by stock for both periods and all age classes were 57,188 Nelson River, 49,271 Bristol Bay, and 11,697 Bear River. First-period local stock contribution was 66.3%, second period 50.4%, with 33.7% and 49.6% being non-local stocks, respectively. In composite, North Peninsula local stocks contributed 58.3%, and non-local stocks 41.7% of the sockeye harvest.

Cape Seniavin to Strogonof Point

Total sockeye catch for 8-14 July was 453,538, of which 31.9% were age-2.2, and 56.1% age-2.3 fish. Estimated stock contributions for age-2.2 fish were 87.6% Bristol Bay, 8.3% Bear River, and 4.1% Nelson River fish (Figure 6). Age-2.3 sockeye stock contributions were 77.2% Bristol Bay, 15.3% Nelson River, and 7.5% Bear River (Figure 7). During the period 15-21 July, 307,288 sockeye were caught, of which 44.3% were age-2.2 and 43.6% age-2.3 fish. Percent contribution by stock (age-2.2) was 58.6% Bristol Bay, 28.1% Bear River, and 13.3% Nelson River (Figure 6). Age-2.3 catch was an estimated 89.2% Bristol Bay, 7.1% Nelson River, and 3.7% Bear River (Figure 7).

Total sockeye catch combining periods and ages was 671,501 fish, of which an estimated 524,289 were Bristol Bay, 72,750 Nelson River, and 74,461 Bear River. Local stock contributions for 8-14 July and 15-21 July were 19.0% and 18.7%, respectively. Combined, local stocks contributed 18.9%, and non-local stocks 81.1% of the sockeye harvest within this area.

Harbor Point to Strogonof Point

In total 881,943 sockeye salmon were harvested during 8-21 July 1990. Including all age classes, 13.4% were caught in the Harbor Point to Cape Seniavin area, and 86.6% in the Cape Seniavin to Strogonof Point area. Assuming stock composition estimates generated for the age-2.2 and -2.3 fish were applicable to all other age classes present, then 10.9% were of Bear River origin, 15.9% were from Nelson River, and 73.2% were from Bristol Bay (Figure 8).

DISCUSSION

Reported stock composition and catch estimates were accurate and without bias in misclassification towards North Peninsula or Bristol Bay stocks. The Monte Carlo simulations support this claim for the age-2.3 analyses. The age-2.2 model, having a higher mean classification accuracy was not evaluated. However, the probability that substantial bias exists for this model is remote, considering the observed precision of the correction procedure for the age-2.3 known proportions.

Error in the catch estimates undoubtedly exists because of the absence of minor North Peninsula stocks within the analyses. The extent to which these stocks would correctly or incorrectly classify to stock of origin based on their scale patterns is speculative. However, the catch contributions from these stocks is probably minor considering that they collectively constitute 17% of all North Peninsula escapements. Error could also surface from our approach of estimating catches of minor age classes using stock composition estimates derived from age-2.2 and -2.3 analyses. The magnitude of such error is probably negligible because minor age classes comprised approximately 7% of catches within the Harbor Point to Cape Seniavin area and 12.5% within the Cape Seniavin to Strogonof Point area during periods investigated.

The numbers of Bristol Bay sockeye caught within the Harbor Point and Strogonof Point areas are substantially higher than those found by Geiger (1989) within the same areas and periods. However this could be attributed to the inclusion in the analysis of Bristol Bay stocks other than Ugashik, relative differences in run size, or aberrant migration behavior. Migrational pathways presented by Straty (1975) indicate that sockeye salmon migrating nearshore in the North Peninsula area comprise a small fraction of the total Bristol Bay run. However, the number of Bristol Bay sockeye salmon caught within the North Peninsula area in 1990 may not be deviant but reflect a near-record run.

If a North Peninsula SPA study is performed again the following changes should be made: (1) standard scales for each stock should be collected from escapement samples; (2) minor stock, catch contributions should be quantified; and (3) scale variables should incorporate information specific to freshwater annular zone for each stock.

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Table 1. Harbor Point to Cape Seniavin commercial salmon catch by week and species, 1990.

Calendar Week	# Permits Purse Seine	Drift Net	Set Net	Number of Salmon Chinook	Sockeye	Coho	Pink	Chum	Total
06/03-06/09	0	4	0	169	45	0	0	48	262
06/10-06/16	0	3	0	[a]	[a]	[a]	[a]	[a]	[a]
06/17-06/23	0	9	3	969	9,925	129	0	738	11,761
06/24-06/30	0	56	2	483	46,457	0	0	1,875	48,815
07/01-07/07	0	0	1	[a]	[a]	[a]	[a]	[a]	[a]
07/08-07/14	0	63	2	44	57,713	0	1	7,407	65,165
07/15-07/21	0	86	2	59	60,444	9	19	9,793	70,324
07/22-07/28	0	86	0	19	80,415	48	304	4,408	85,194
07/29-08/04	0	90	0	16	88,769	73	1,274	2,791	92,923
08/05-08/11	1	115	1	24	102,797	226	15,160	2,353	120,560
08/12-08/18	0	128	1	31	156,751	1,914	896	1,069	160,661
08/19-08/25	0	108	2	8	137,934	5,659	489	667	144,757
08/26-09/01	0	85	1	5	84,296	7,071	271	210	91,853
09/02-09/08	0	58	0	2	44,841	4,835	88	28	49,794
09/09-09/15	0	16	0	0	9,476	671	2	2	10,151
Totals	1	141	4	2,199	880,101	20,635	18,504	31,574	953,013

[a] Confidentiality rules prevent release of catch data for three and less permit holders.

Table 2. Cape Seniavin to Strogonof Point commercial salmon catch by week and species, 1990.

Calendar Week	# Permits Purse Seine	Drift Net	Set Net	Chinook	Number of Salmon Sockeye	Coho	Pink	Chum	Total
06/17-06/23	0	1	0	[a]	[a]	[a]	[a]	[a]	[a]
06/24-06/30	0	55	1	254	71,161	0	0	62	71,477
07/01-07/07	0	0	1	[a]	[a]	[a]	[a]	[a]	[a]
07/08-07/14	0	134	3	157	453,538	4	1	4,462	458,162
07/15-07/21	0	124	0	67	307,288	35	15	2,062	309,467
07/22-07/28	0	43	0	56	54,089	59	59	865	55,128
07/29-08/04	0	25	0	4	17,829	117	334	188	18,472
08/05-08/11	0	11	0	2	6,642	249	222	74	7,189
08/12-08/18	0	17	1	0	16,635	934	183	26	17,778
08/19-08/25	0	8	2	1	6,920	2,193	45	2	9,161
08/26-09/01	0	3	1	0	3,095	2,407	0	0	5,502
09/02-09/08	0	6	3	0	1,645	5,359	11	0	12,517
09/09-09/15	0	0	1	[a]	[a]	[a]	[a]	[a]	[a]
Drift net				538	932,732	3,807	870	7,741	945,688
Set net				7	10,168	8,658	0	0	18,833
Totals	0	146	4	545	942,900	12,465	870	7,741	964,521

[a] Confidentiality rules prevent release of catch data for three and less permit holders.

Table 3. Estimated age composition of sockeye salmon catches from Harbor Point to Cape Seniavin by temporal strata, 1990.

Date	Sample Size		0.2	0.3	1.2	2.1	0.4	1.3	2.2	1.4	2.3	3.2	2.4	Total
			Age Classes											
6/03-6/23	348	Percent	0.0	3.2	2.0	0.0	0.3	18.7	14.4	0.3	59.2	0.3	1.7	100.0
		Numbers	0	323	205	0	29	1,907	1,467	29	6,043	29	176	10,208
		SE	0	96	77	0	29	214	192	29	269	29	71	
6/24-6/30	520	Percent	0.0	4.2	1.7	0.0	0.0	11.5	14.2	0.0	67.5	0.2	0.6	100.0
		Numbers	0	1,965	804	0	0	5,360	6,611	0	31,358	89	268	46,457
		SE	0	410	266	0	0	652	712	0	955	89	154	
7/08-7/14	534	Percent	0.0	0.2	0.4	0.0	0.0	2.8	11.4	0.0	84.5	0.0	0.7	100.0
		Numbers	0	108	216	0	0	1,621	6,593	0	48,743	0	432	57,713
		SE	0	108	153	0	0	413	795	0	906	0	216	
7/15-7/21	610	Percent	0.0	0.3	0.7	0.0	0.2	3.9	25.4	0.5	68.5	0.0	0.5	100.0
		Numbers	0	198	396	0	99	2,378	15,359	297	41,419	0	297	60,444
		SE	0	140	198	0	99	476	1,066	171	1,138	0	171	
7/22-7/28	577	Percent	0.2	0.2	2.1	0.0	0.0	6.9	31.5	0.0	58.2	0.5	0.3	100.0
		Numbers	139	139	1,672	0	0	5,575	25,365	0	46,827	418	279	80,415
		SE	139	139	478	0	0	851	1,557	0	1,652	241	197	
7/29-8/04	552	Percent	0.2	1.4	7.4	0.0	0.0	32.4	27.7	0.0	30.4	0.2	0.2	100.0
		Numbers	161	1,287	6,593	0	0	28,786	24,604	0	27,017	161	161	88,769
		SE	161	452	992	0	0	1,770	1,693	0	1,740	161	161	
8/05-8/11	565	Percent	0.0	0.2	6.7	0.0	0.0	34.5	38.9	0.0	19.5	0.2	0.0	100.0
		Numbers	0	182	6,914	0	0	35,479	40,027	0	20,014	182	0	102,797
		SE	0	182	1,084	0	0	2,058	2,111	0	1,714	182	0	
8/12-8/18	570	Percent	0.0	0.4	13.0	0.0	0.0	29.8	47.9	0.0	8.6	0.4	0.0	100.0
		Numbers	0	550	20,350	0	0	46,750	75,075	0	13,475	550	0	156,751
		SE	0	389	2,209	0	0	3,006	3,283	0	1,842	389	0	
8/19-8/25	570	Percent	0.0	0.2	4.0	0.0	0.0	13.3	59.8	0.0	22.5	0.2	0.0	100.0
		Numbers	0	242	5,566	0	0	18,391	82,518	0	30,975	242	0	137,934
		SE	0	242	1,138	0	0	1,966	2,835	0	2,413	242	0	
8/26-9/01	548	Percent	0.2	0.0	4.6	0.2	0.0	20.1	54.9	0.0	19.9	0.2	0.0	100.0
		Numbers	154	0	3,846	154	0	16,921	46,301	0	16,767	154	0	84,296
		SE	154	0	752	154	0	1,444	1,793	0	1,439	154	0	

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Table 3. (page 2 of 2)

Date	Sample Size		Age Classes 0.2	0.3	1.2	2.1	0.4	1.3	2.2	1.4	2.3	3.2	2.4	Total
9/02-9/15	557	Percent	0.0	0.0	2.9	0.0	0.0	8.8	70.0	0.0	17.6	0.7	0.0	100.0
		Numbers	0	0	1,560	0	0	4,778	38,032	0	9,557	390	0	54,317
		SE	0	0	385	0	0	652	1,055	0	877	195	0	
Total	5,951	Percent	0.1	0.6	5.5	0.0	0.0	19.1	41.1	0.0	33.2	0.3	0.2	100.0
		Numbers	454	4,994	48,122	154	128	167,946	361,952	326	292,195	2,215	1,613	880,101
		SE	263	822	3,068	154	103	4,937	5,933	174	4,884	630	412	

Table 4. Estimated age composition of sockeye salmon catches from Cape Seniavin to Strogonof Point by temporal strata, 1990.

Date	Sample Size		Age Classes 0.3	1.2	0.4	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Total
6/17-6/30	543	Percent	2.2	0.7	0.4	10.9	10.9	0.0	72.0	0.6	1.8	0.6	100.0
		Numbers	1,597	532	266	7,851	7,851	0	52,032	399	1,331	399	72,259
		SE	456	265	188	966	966	0	1,393	230	417	230	
7/01-7/14	565	Percent	1.4	2.8	0.0	5.0	31.9	0.0	56.1	2.7	0.2	0.0	100.0
		Numbers	6,464	12,927	0	22,623	145,433	0	256,124	12,119	808	0	456,498
		SE	2,271	3,189	0	4,172	8,956	0	9,539	3,090	808	0	
7/15-7/21	576	Percent	0.3	3.0	0.0	4.3	44.3	0.0	43.6	4.0	0.3	0.2	100.0
		Numbers	1,067	9,069	0	13,337	136,039	0	133,905	12,270	1,067	533	307,288
		SE	754	2,169	0	2,611	6,365	0	6,354	2,509	754	533	
7/22-7/28	552	Percent	0.7	4.9	0.0	8.2	30.3	0.7	47.5	5.1	0.9	1.8	100.0
		Numbers	392	2,646	0	4,409	16,364	392	25,673	2,744	490	980	54,089
		SE	195	497	0	631	1,058	195	1,151	506	218	307	
7/29-8/04	546	Percent	2.7	6.4	0.0	15.9	27.7	0.4	41.4	5.1	0.4	0.0	100.0
		Numbers	490	1,143	0	2,841	4,931	65	7,380	914	65	0	17,829
		SE	125	187	0	280	342	46	376	168	46	0	
8/05-8/11	555	Percent	1.1	11.5	0.0	24.3	38.2	0.0	24.5	0.2	0.2	0.0	100.0
		Numbers	72	766	0	1,616	2,537	0	1,628	12	12	0	6,642
		SE	29	90	0	121	137	0	121	12	12	0	
8/12-8/18	432	Percent	0.2	7.6	0.0	19.7	49.1	0.0	22.2	1.2	0.0	0.0	100.0
		Numbers	39	1,271	0	3,273	8,163	0	3,697	193	0	0	16,635
		SE	39	213	0	319	401	0	333	86	0	0	
8/19-9/15	537	Percent	0.6	12.7	0.0	25.7	47.3	0.0	13.8	0.0	0.0	0.0	100.0
		Numbers	65	1,476	0	2,996	5,515	0	1,607	0	0	0	11,660
		SE	38	167	0	220	251	0	174	0	0	0	
Total	4,306	Percent	1.1	3.2	0.0	6.3	34.7	0.0	51.1	3.0	0.4	0.2	100.0
		Numbers	10,186	29,830	266	58,946	326,833	457	482,046	28,651	3,773	1,912	942,900
		SE	2,448	3,912	188	5,079	11,097	201	11,616	4,024	1,202	657	

Table 5. Estimated age composition of the sockeye salmon catch within the Ugashik, Egegik, and Naknek-Kvichak Districts, 1990.

District	Sample Size		Age Classes 0.2	0.3	1.2	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Total
Ugashik	2,650	Number	2,950	25,503	318,815	516,656	673,465	12,557	590,690	2,907	720	0	2,144,263
		Percent	0.14	1.19	14.87	24.09	31.41	0.59	27.55	0.14	0.03	0.00	
Egegik	5,258	Number	167	13,054	1,203,574	1,215,720	3,248,740	9,369	4,192,760	166,725	21,097	15,580	10,086,786
		Percent	0.00	0.13	11.93	12.05	32.21	0.09	41.57	1.65	0.21	0.15	
Naknek-Kvichak	7,527	Number	18,561	22,029	1,985,272	3,867,918	7,702,820	19,827	3,491,358	12,627	0	2,020	17,122,432
		Percent	0.11	0.13	11.59	22.59	44.99	0.12	20.39	0.07	0.00	0.01	

Table 6. Estimated age composition of sockeye escapement from Bear River by week, 1990.

Calendar Week	Sample Size		Age Classes 1.2	2.1	1.3	2.2	3.1	2.3	3.2	2.4	3.3	Total
6/03-6/09	0	Percent	16.1	0.6	6.2	35.4	0.0	33.5	7.5	0.6	0.0	100.0
		Numbers	26	1	10	57	0	54	12	1	0	161
6/10-6/16	0	Percent	16.4	0.5	6.3	35.4	0.0	33.7	7.3	0.5	0.0	100.0
		Numbers	176	5	68	381	0	362	78	5	0	1,075
6/17-6/23	0	Percent	16.4	0.5	6.4	35.5	0.0	33.7	7.3	0.5	0.0	100.0
		Numbers	424	12	165	919	0	872	188	12	0	2,591
6/24-6/30	220	Percent	16.8	0.5	5.5	36.3	0.2	33.3	6.9	0.5	0.1	100.0
		Numbers	1,836	60	599	3,970	20	3,642	758	50	10	10,945
7/01-7/07	217	Percent	16.6	1.2	1.7	37.7	0.6	36.8	4.7	0.5	0.3	100.0
		Numbers	11,076	815	1,139	25,221	401	24,589	3,158	305	200	66,905
7/08-7/14	223	Percent	14.0	1.6	1.5	36.1	0.2	42.5	3.6	0.4	0.1	100.0
		Numbers	9,205	1,053	969	23,682	101	27,932	2,376	286	50	65,656
7/15-7/21	214	Percent	15.7	0.7	2.7	63.4	0.0	12.3	5.1	0.0	0.0	100.0
		Numbers	8,098	385	1,418	32,678	0	6,319	2,651	24	0	51,572
7/22-7/28	0	Percent	13.3	1.9	3.7	69.4	0.0	8.2	3.5	0.0	0.0	100.0
		Numbers	6,633	926	1,857	34,510	0	4,069	1,749	0	0	49,744
7/29-8/04	214	Percent	11.4	2.7	4.3	71.3	0.0	8.0	2.2	0.0	0.0	100.0
		Numbers	7,573	1,814	2,860	47,212	0	5,321	1,457	0	0	66,237
8/05-8/11	187	Percent	8.3	1.1	1.9	78.6	0.0	9.0	1.2	0.0	0.0	100.0
		Numbers	4,036	522	921	38,362	0	4,393	597	0	0	48,831
8/12-8/18	214	Percent	4.3	0.0	0.5	85.3	0.0	7.7	2.1	0.0	0.0	100.0
		Numbers	1,815	0	206	35,631	0	3,235	889	0	0	41,776
8/19-8/25	0	Percent	2.3	0.0	0.5	87.9	0.0	6.5	2.8	0.0	0.0	100.0
		Numbers	1,065	0	213	40,038	0	2,982	1,278	0	0	45,575
8/26-9/01	0	Percent	2.3	0.0	0.5	87.9	0.0	6.5	2.8	0.0	0.0	100.0
		Numbers	961	0	192	36,119	0	2,690	1,153	0	0	41,114

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Table 6. (page 2 of 2)

Calendar Week	Sample Size		Age Classes 1.2	2.1	1.3	2.2	3.1	2.3	3.2	2.4	3.3	Total
9/02-9/08	0	Percent	2.3	0.0	0.5	87.9	0.0	6.5	2.8	0.0	0.0	100.0
		Numbers	1,276	0	255	47,982	0	3,573	1,531	0	0	54,618
Total	1,489	Percent[a]	9.9	1.0	2.0	67.1	0.1	16.5	3.3	0.1	0.0	100.0
		Numbers	54,200	5,593	10,872	366,762	522	90,033	17,875	683	260	546,800

[a] Percentages are calculated on escapement numbers, not samples. Sample sizes are for the week indicated, and age composition is calculated daily. When the date falls between two sample dates age composition is interpolated. When the date falls on a sample date, before the first or after the last sample, calculations are based upon a single date.

Table 7. Estimated age composition of sockeye salmon escapement from Nelson River (Sapsuk River-Hoodoo Lake) by calendar week, based on Nelson Lagoon terminal catch samples, 1990.

Calendar Week	Sample Size		0.2	0.3	1.2	2.1	0.4	1.3	Age Classes 2.2	1.4	2.3	3.2	2.4	3.3	Total
6/03-6/09	0	Percent	0.0	0.0	3.1	0.0	0.0	21.9	15.6	0.0	53.1	3.1	0.0	3.1	100.0
		Numbers	0	0	1	0	0	7	5	0	17	1	0	1	32
6/10-6/16	522	Percent	0.0	0.7	1.8	0.0	0.0	22.7	15.3	0.5	53.8	2.7	0.5	1.8	100.0
		Numbers	0	4	10	0	0	126	85	3	298	15	3	10	554
6/17-6/23	339	Percent	0.0	0.6	2.5	0.0	0.0	19.1	15.8	0.1	58.0	2.2	0.8	0.9	100.0
		Numbers	0	24	96	0	0	746	619	3	2,266	86	33	37	3,910
6/24-6/30	510	Percent	0.0	0.7	1.5	0.0	0.0	17.7	20.0	0.1	56.1	2.6	0.6	0.6	100.0
		Numbers	0	330	644	0	0	7,816	8,807	63	24,718	1,141	275	283	44,077
7/01-7/07	518	Percent	0.0	0.7	1.4	0.0	0.0	18.2	22.3	0.0	54.9	1.4	0.4	0.6	100.0
		Numbers	0	597	1,151	0	0	14,849	18,189	40	44,861	1,148	357	463	81,655
7/08-7/14	519	Percent	0.0	0.4	3.1	0.0	0.0	12.9	44.4	0.0	36.7	1.6	0.4	0.4	100.0
		Numbers	0	258	2,070	0	13	8,480	29,233	13	24,214	1,086	280	250	65,897
7/15-7/21	520	Percent	0.0	0.9	7.5	0.0	0.1	12.3	52.8	0.1	24.0	1.4	0.7	0.1	100.0
		Numbers	1	285	2,397	0	43	3,921	16,803	43	7,637	430	207	33	31,802
7/22-7/28	561	Percent	0.1	1.3	11.4	0.0	0.1	12.7	50.4	0.1	22.7	0.8	0.5	0.0	100.0
		Numbers	6	87	764	0	6	852	3,389	6	1,523	56	31	0	6,720
7/29-8/04	576	Percent	0.1	1.0	11.4	0.0	0.0	12.1	45.0	0.0	28.9	1.3	0.1	0.2	100.0
		Numbers	6	63	688	0	0	730	2,722	0	1,748	77	6	14	6,053[a]
Total	5,578	Percent[b]	0.0	0.7	3.2	0.0	0.0	15.6	33.2	0.1	44.6	1.7	0.5	0.5	100.0
		Numbers	13	1,648	7,821	0	62	37,527	79,852	171	107,282	4,040	1,192	1,091	240,700

[a] For 7/29-8/04, the escapement of 6,053 represents post season estimate.

[b] Percentages are calculated on escapement numbers, not samples. Sample sizes are for the week indicated, and age composition is calculated daily. When the date falls between two sample dates age composition is interpolated. When the date falls on a sample date, before the first or after the last sample, calculations are based upon a single date.

Table 8. Classification accuracy for stocks included in age-2.2 all variable forced SPA model.

Actual Stock of Origin	Sample Size	Classified Stock of Origin: Bristol Bay	Nelson River	Bear River
Bristol Bay	458	63.5%	19.9%	16.6%
Nelson River	201	16.9%	80.6%	2.5%
Bear River	215	8.4%	4.6%	87.0%
			$\overline{X}_{CC}$	= 77.0%[a]

[a]Mean correctly classified.

Table 9. Stock composition estimates for age-2.2 mixed stock unknowns from Harbor Point to Cape Seniavin and Cape Seniavin to Strogonof Point, 1990.

			Classified Stock of Origin					
			Bristol Bay		Nelson River		Bear River	
	Sample		Pt.Est.		Pt.Est.		Pt.Est.	
Catch Area	Date	Size	(%)	90% CC[a]	(%)	90% CC[a]	(%)	90% CC[a]
Harbor Point-Cape Seniavin	8-14 July	59	67.3	28.8	22.8	22.1	9.9	16.3
	15-21 July	93	59.6	22.8	20.2	14.4	20.2	17.1
Cape Seniavin-Strogonof Point	8-14 July	147	87.6	19.3	4.2	11.6	8.2	13.5
	15-21 July	203	58.6	15.9	13.3	11.2	28.1	10.7

[a]90% confidence coefficient.

Table 10. Classification accuracy for stocks included in age-2.3 all variable forced SPA model.

Actual Stock of Origin	Sample Size	Classified Stock of Origin: Bristol Bay	Classified Stock of Origin: North Peninsula
Bristol Bay	532	73.1%	26.9%
North Peninsula	399	25.3%	74.7%
			$\overline{X}_{cc}$=73.9[a]

[a]Mean correctly classified.

Table 11. Stock composition estimates for age-2.3 mixed stock unknowns from Harbor Point to Cape Seniavin and Cape Seniavin to Strogonof Point, 1990.

			Classified Stock of Origin			
	Sample		Bristol Bay		North Peninsula	
Catch Area	Date	Size	Pt.Est. (%)	90% CC[a]	Pt.Est. (%)	90% CC[a]
Harbor Point-Cape Seniavin	8-14 July	199	29.1	13.2	70.9	13.2
	15-21 July	199	45.9	13.2	54.1	13.2
Cape Seniavin-Strogonof Point	8-14 July	196	77.2	13.1	22.8	13.1
	15-21 July	175	89.2	13.5	10.8	13.5

[a]90% confidence coefficient.

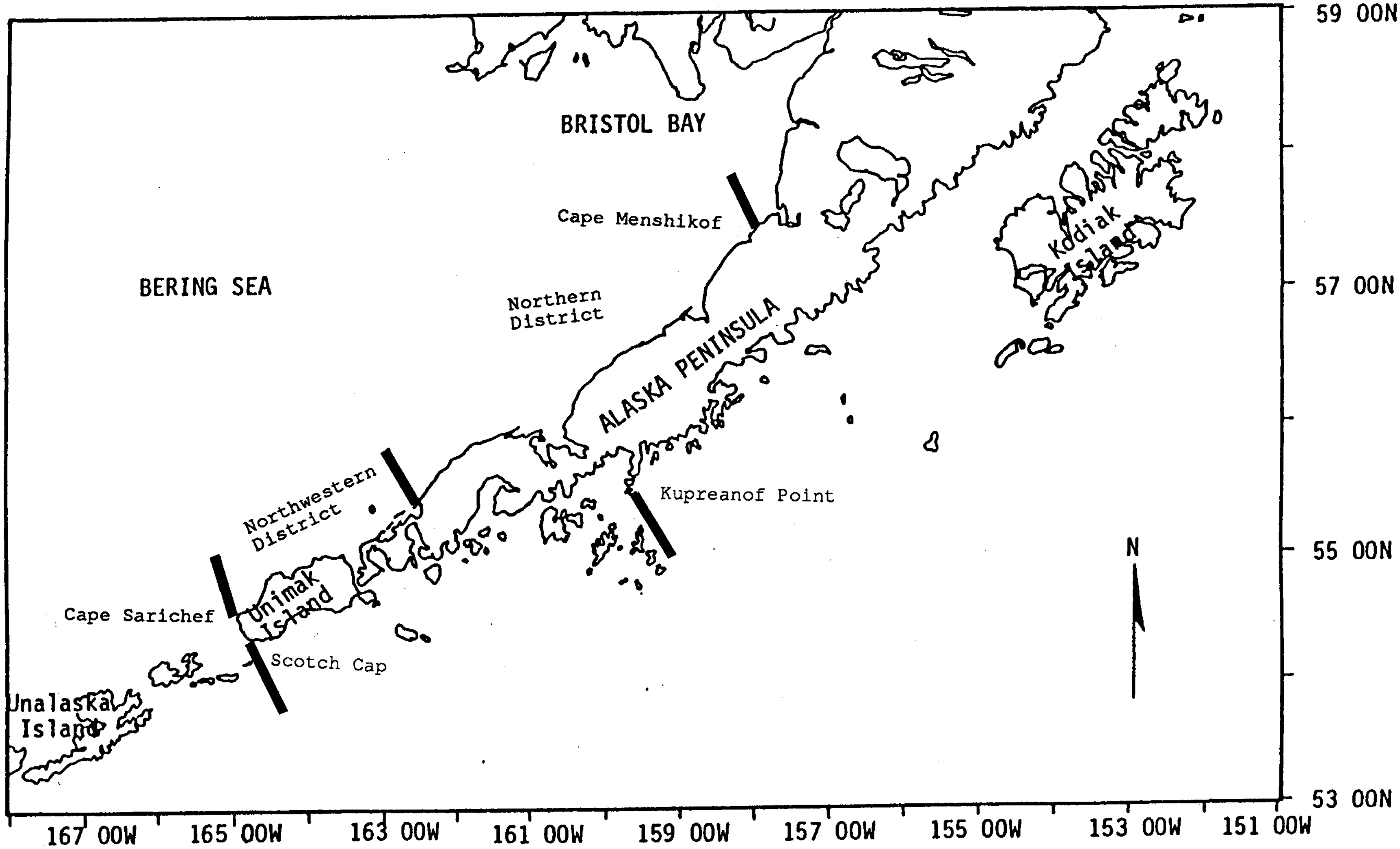


Figure 1. Map depicting boundaries of the Alaska Peninsula Management Area.

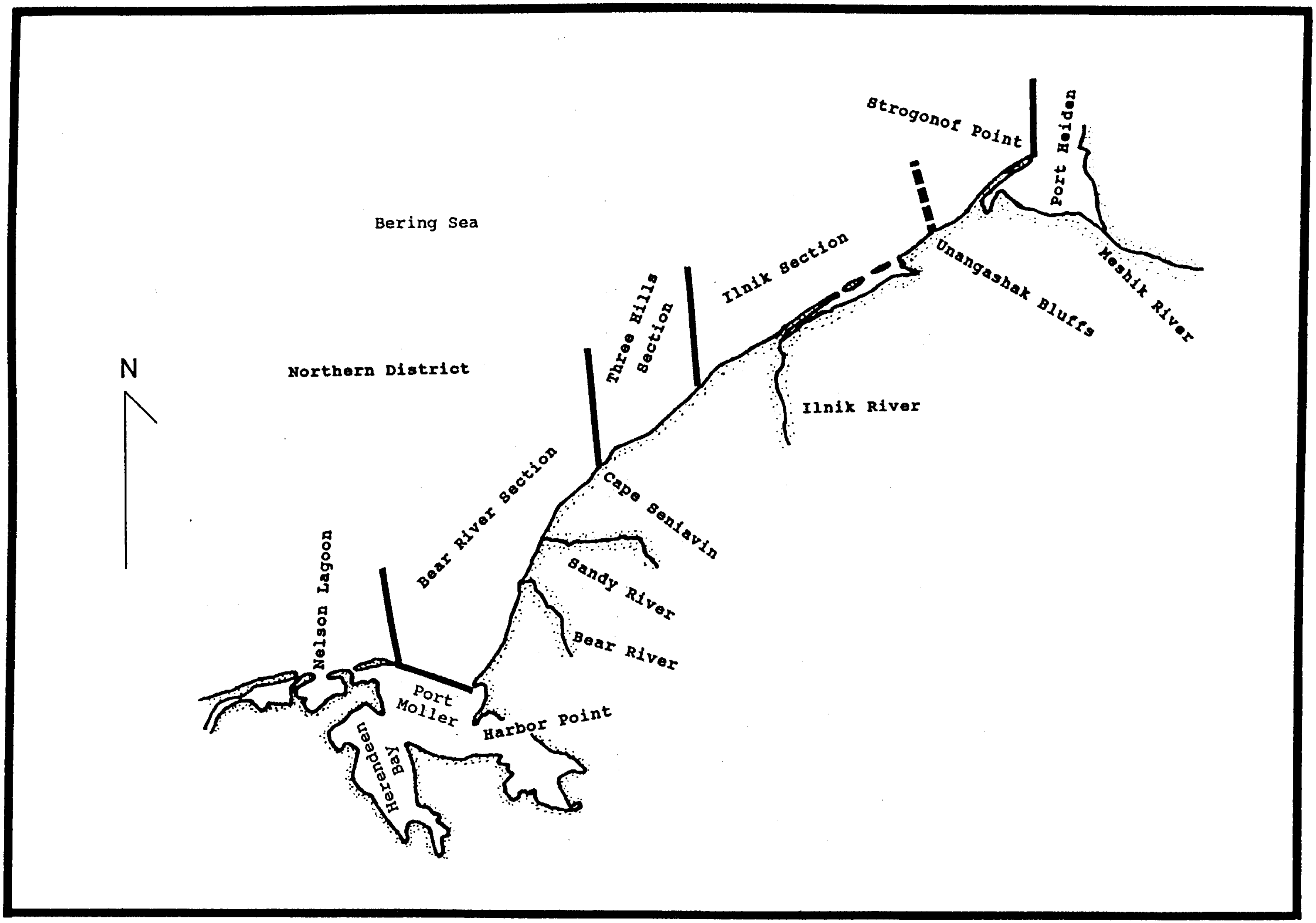


Figure 2. Map of the Harbor Point to Strogonof Point reach, with district sections depicted.

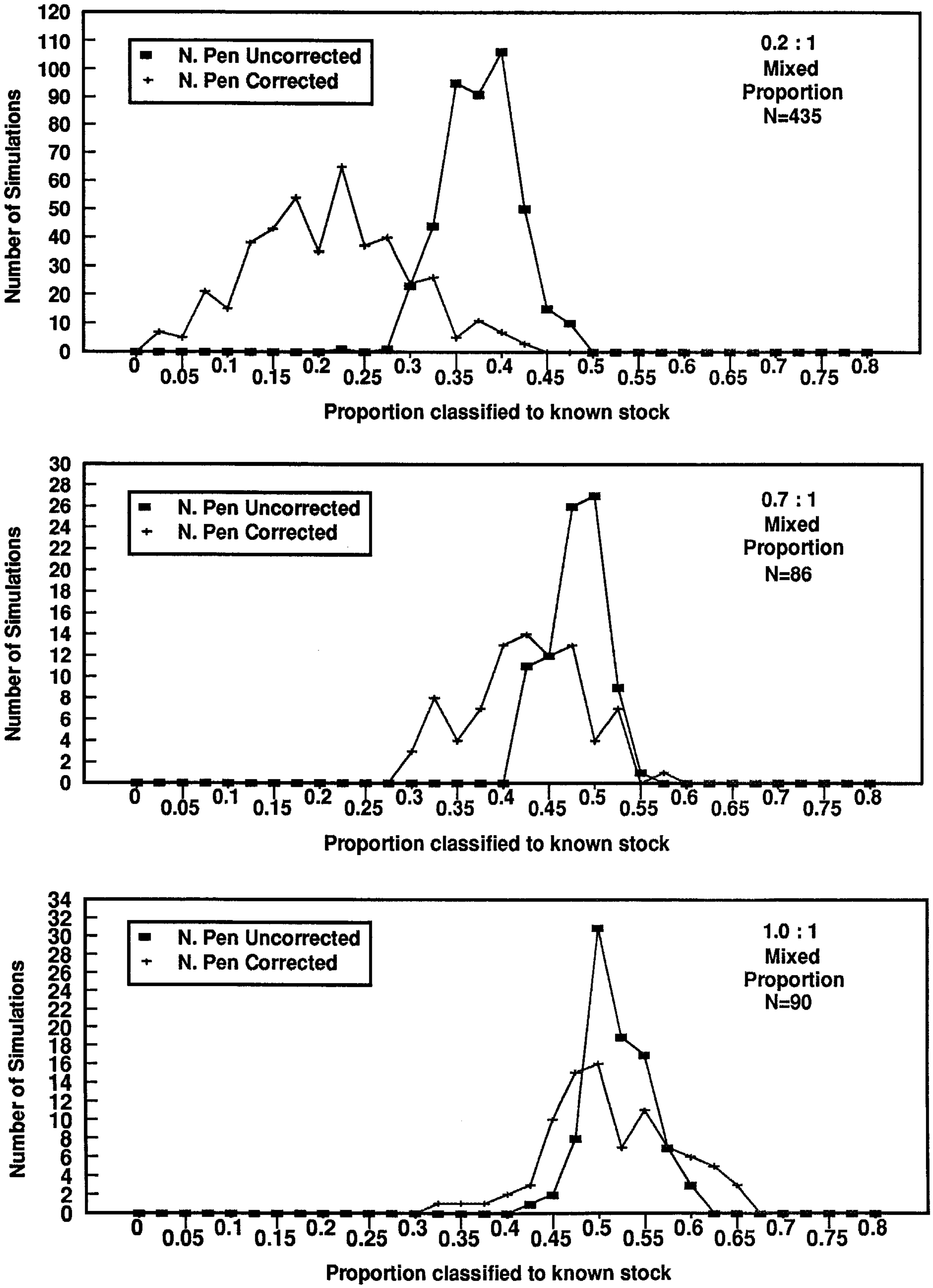


Figure 3. Distributions of Monte Carlo simulation results conducted with known age-2.3 proportions of North Peninsula and Bristol Bay stocks.

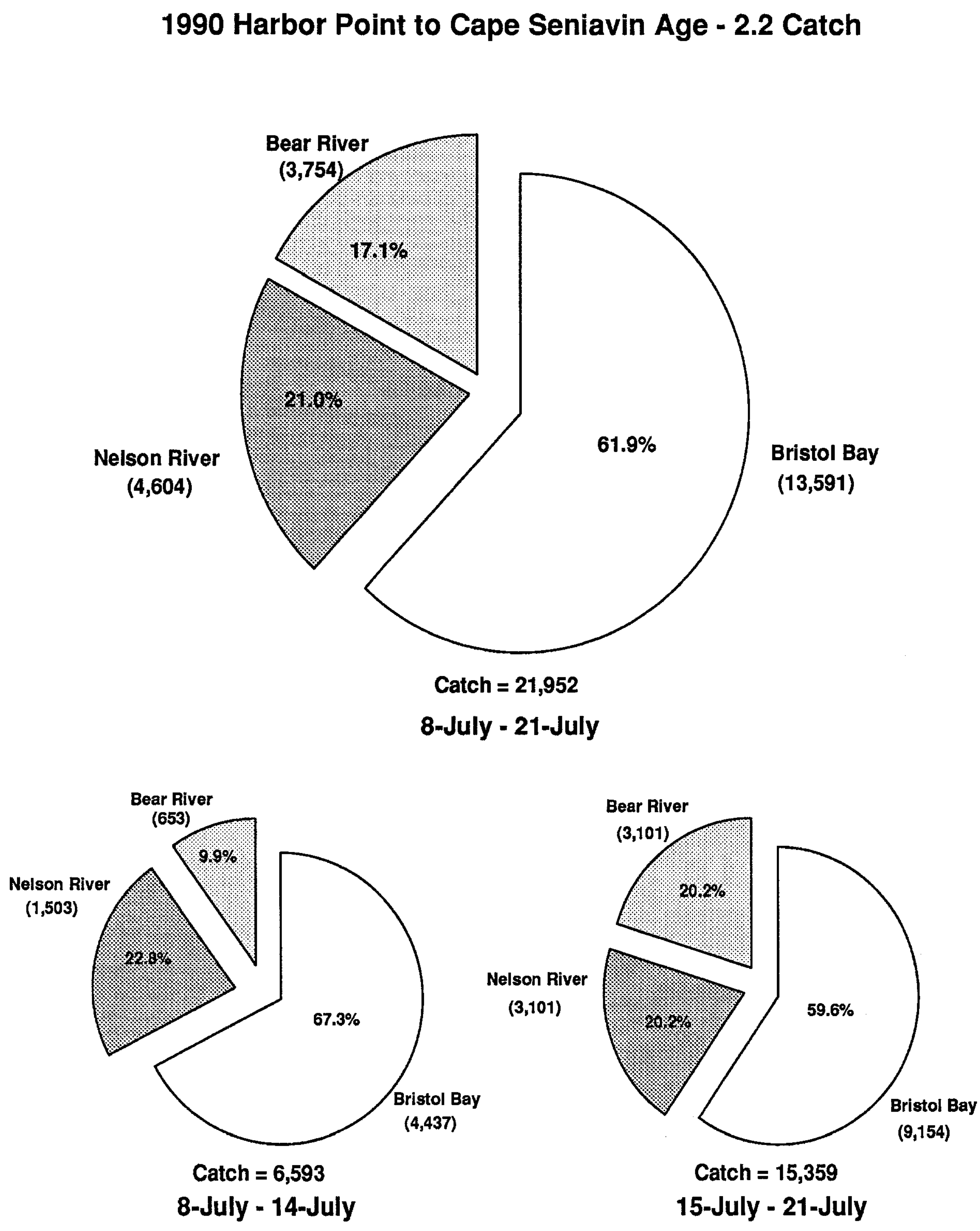


Figure 4. Estimated stock composition of the age-2.2 sockeye salmon catch based on scale pattern analysis, Harbor Point to Cape Seniavin, 1990.

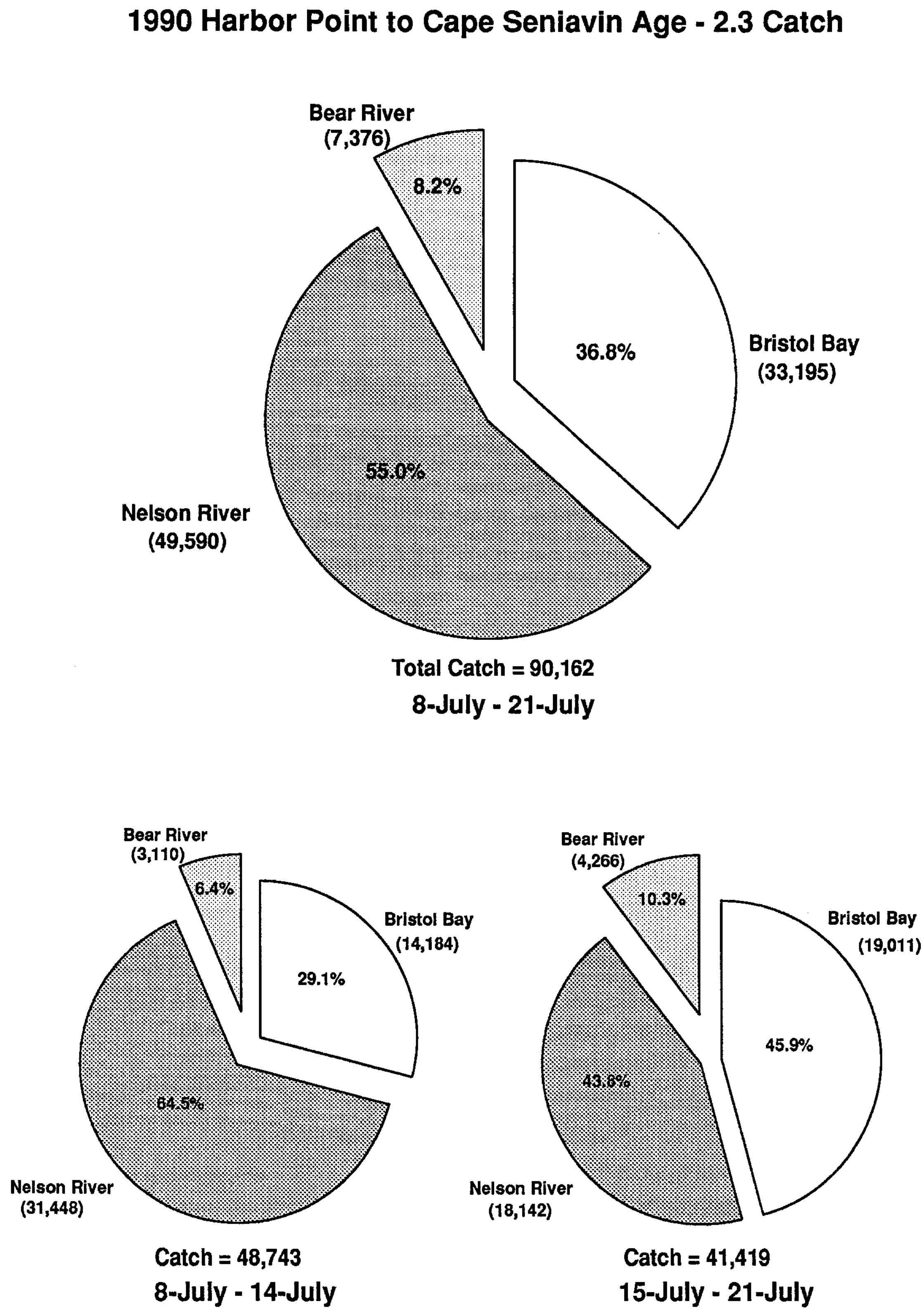
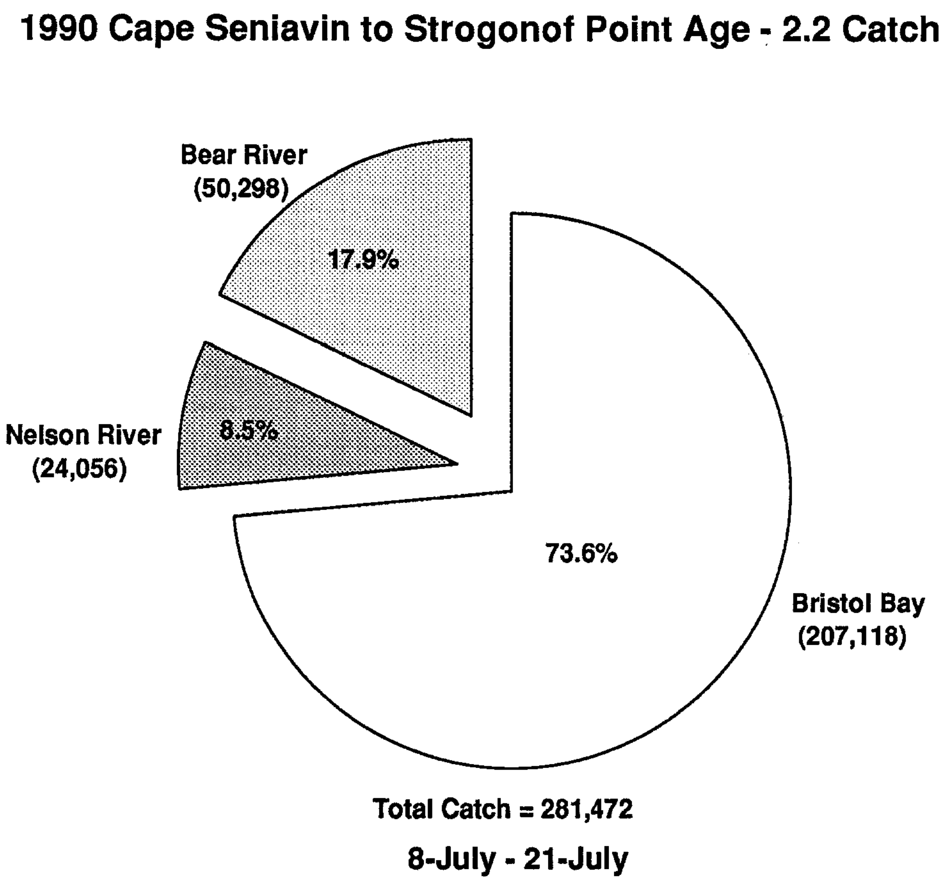
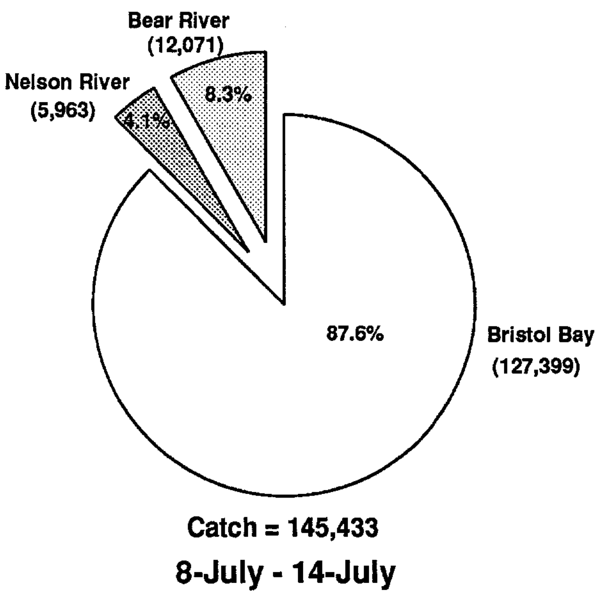


Figure 5. Estimated stock composition of the age-2.3 sockeye salmon catch based on scale pattern analysis, harbor Point to Cape Seniavin, 1990.





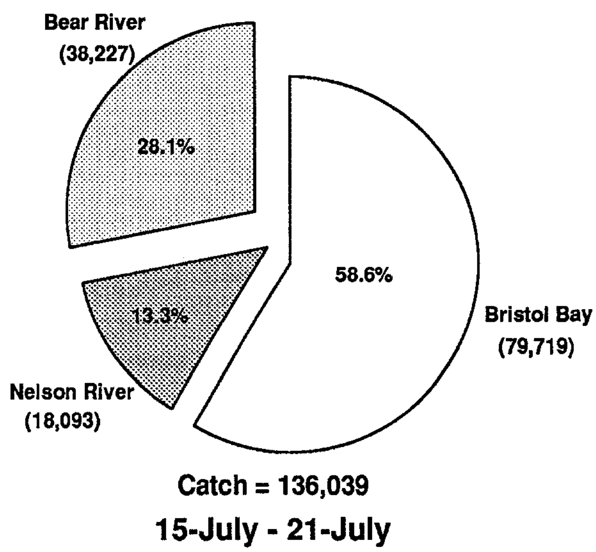


Figure 6. Estimated stock composition of the age-2.2 sockeye salmon catch based on scale pattern analysis, Cape Seniavin to Strogonof Point, 1990.

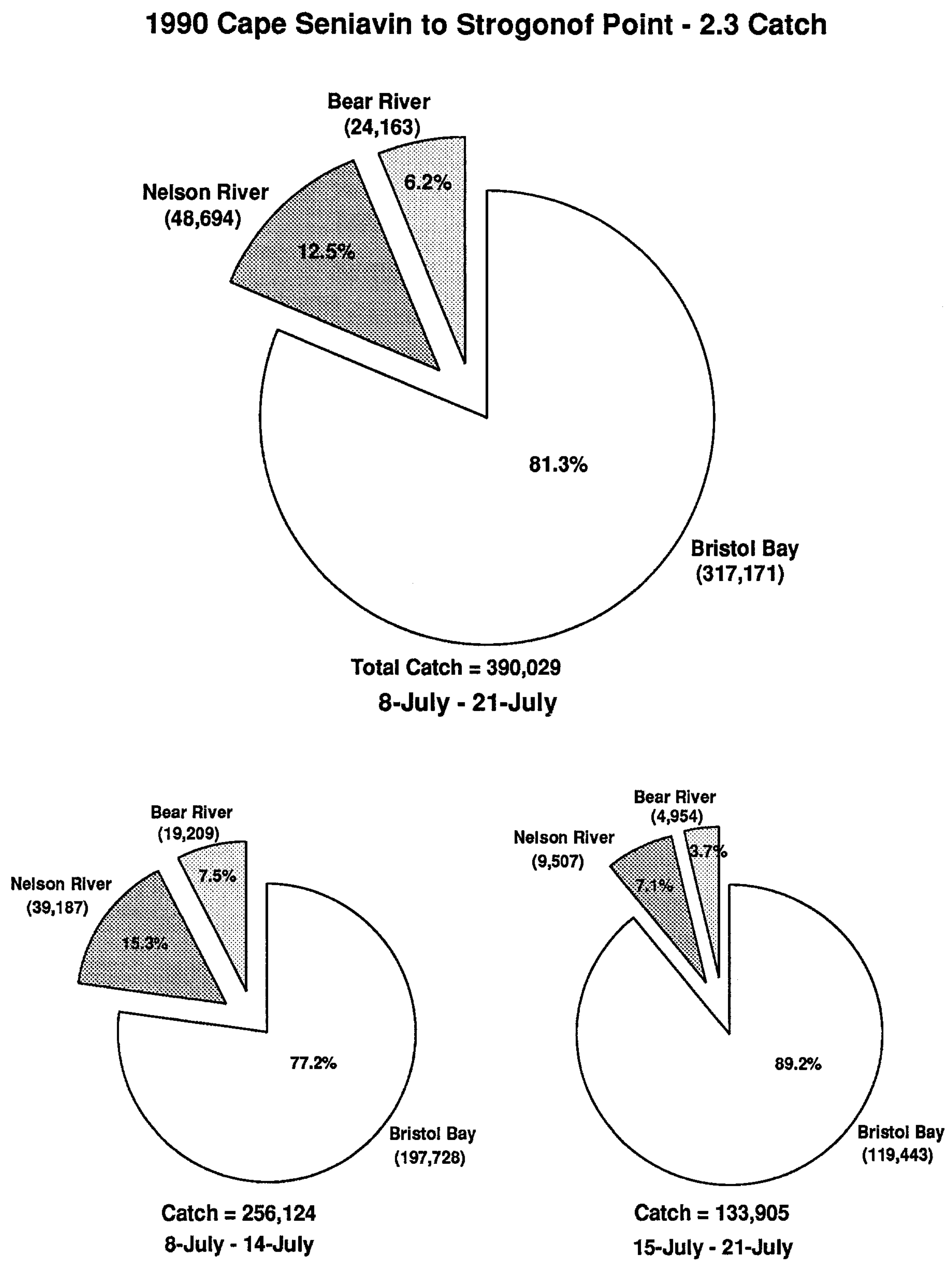
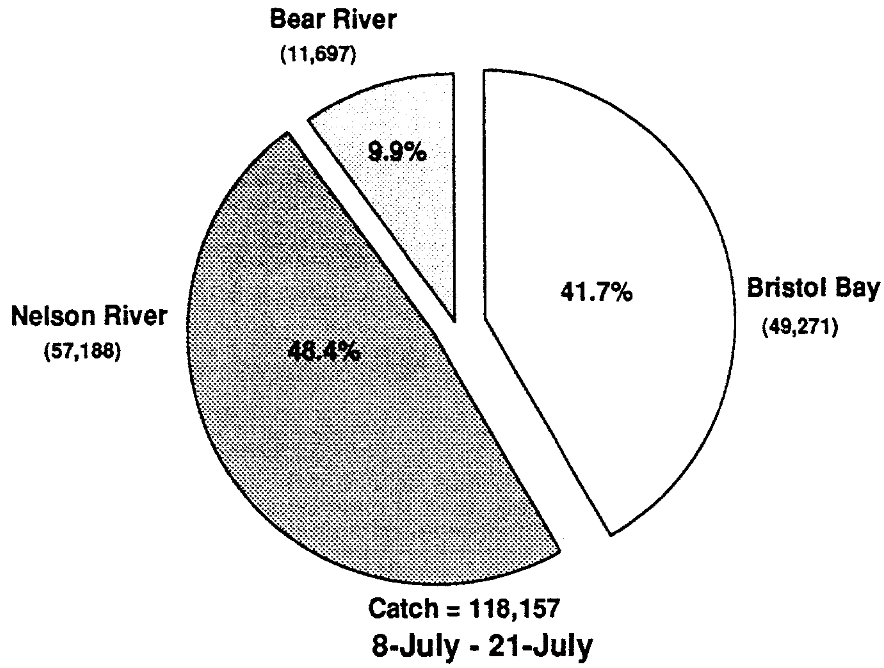


Figure 7. Estimated stock composition of the age-2.3 sockeye salmon catch based on scale analysis, Cape Seniavin to Strogonof Point, 1990.

1990 Harbor Point to Cape Seniavin Catch



1990 Cape Seniavin to Strogonof Point Catch

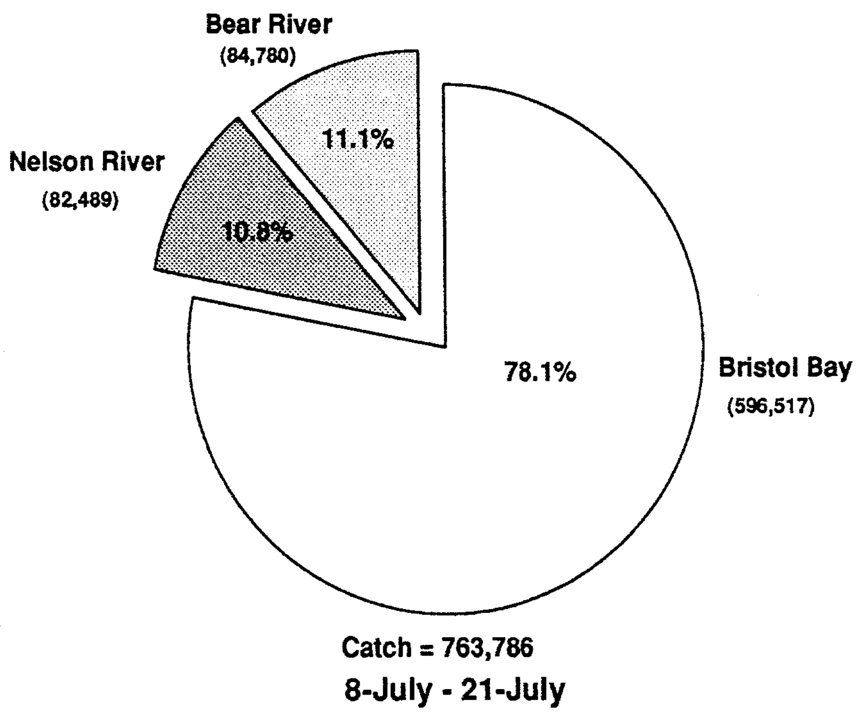
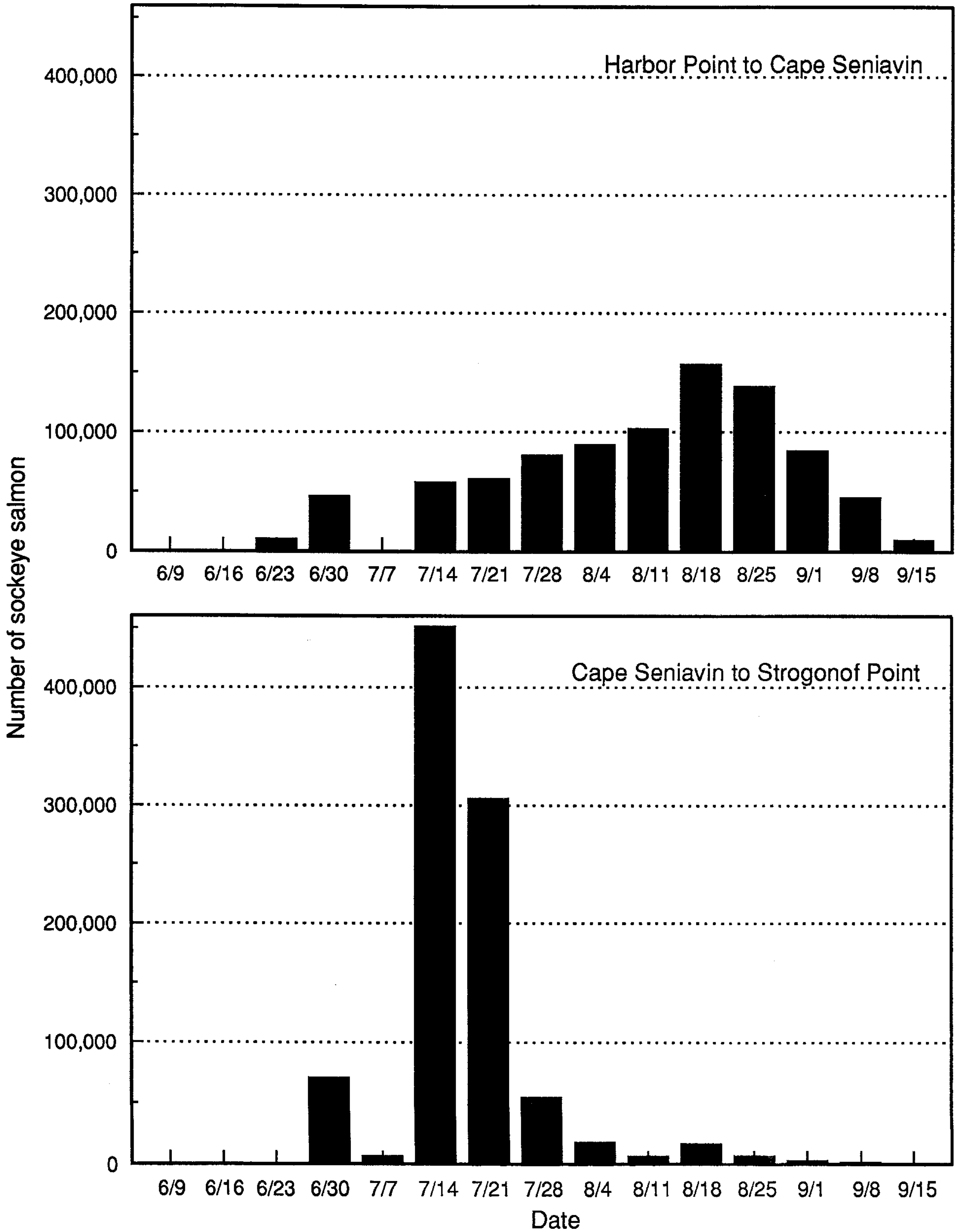
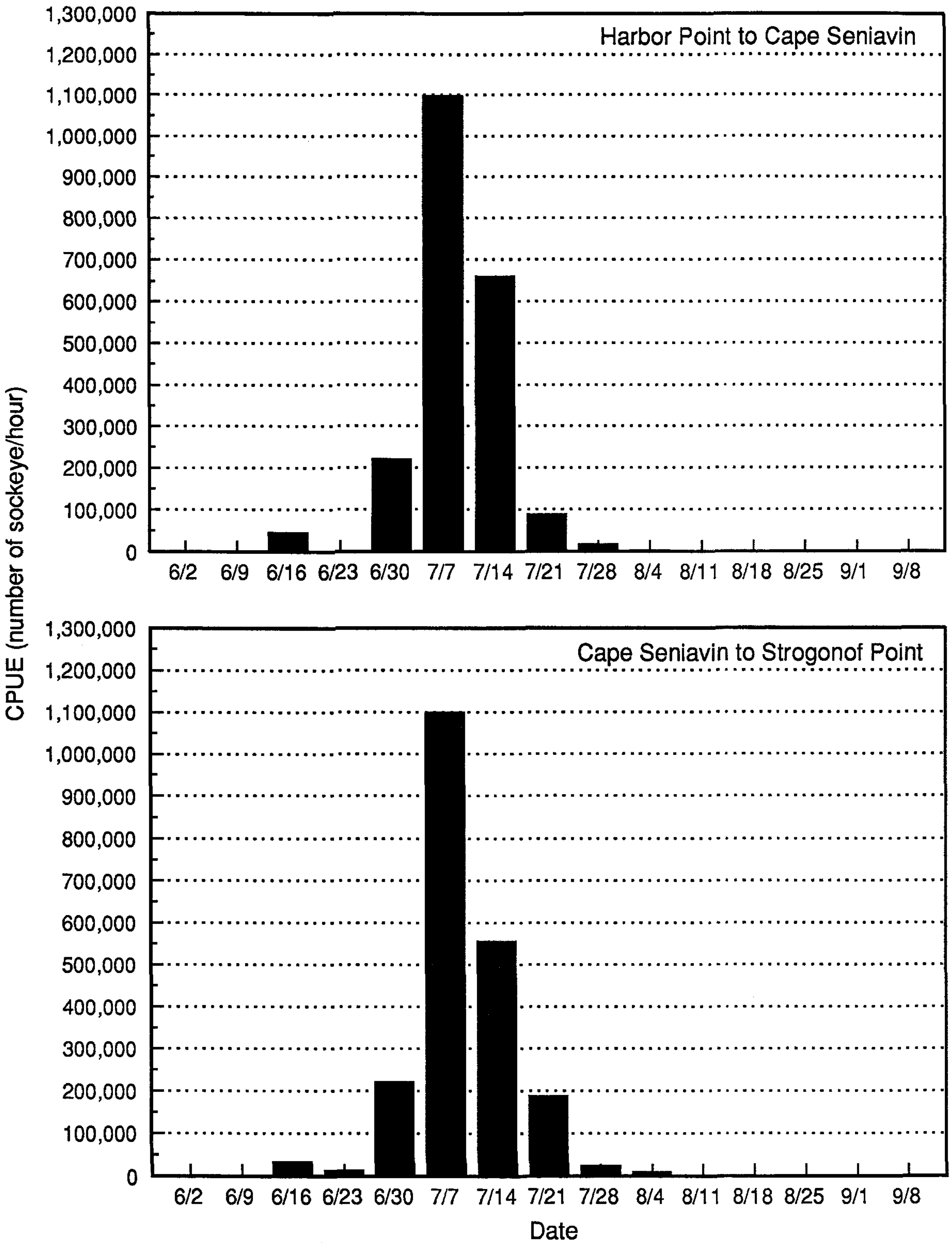


Figure 8. Estimated stock composition (all age classes) of sockeye salmon catch based on scale analysis of age-2.2 and age-2.3 fish, Harbor Point to Cape Seniavin and Cape Seniavin to Strogonof Point, 1990.

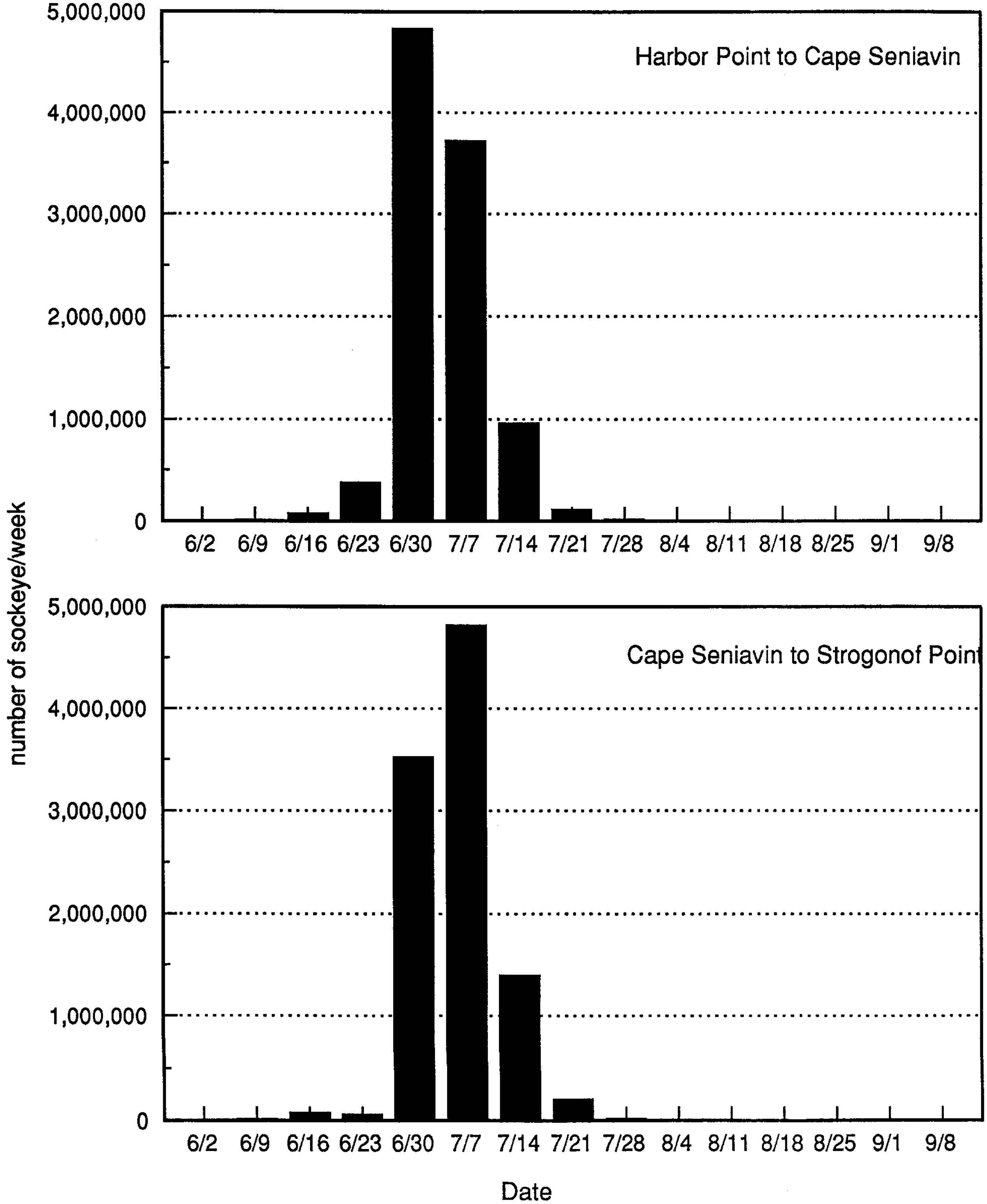
APPENDIX



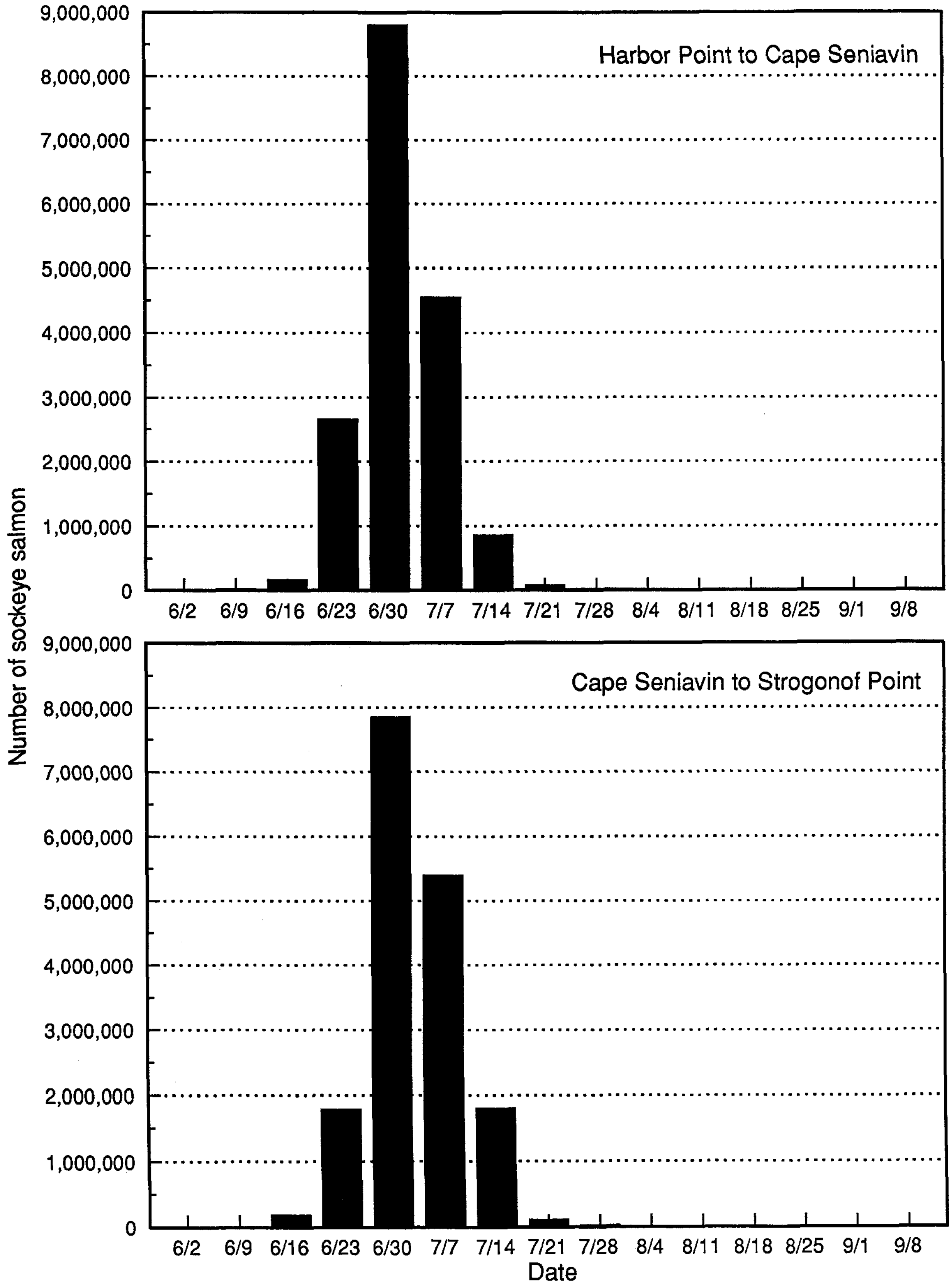
Appendix A.1. Number of sockeye salmon caught by week, Harbor Point to Cape Seniavin (upper panel) and Cape Seniavin to Strogonof Point (lower panel), 1990.



Appendix A.2. Ugashik District sockeye salmon weekly catch, back-calculated in time to the North Peninsula Harbor Point to Cape Seniavin (upper panel) and Cape Seniavin to Strogonof Point (lower panel) areas, 1990.



Appendix A.3. Egegik District sockeye salmon catch, back-calculated in time to the North Peninsula Harbor Point to Cape Seniavin (upper panel) and Cape Seniavin to Strogonof Point (lower panel) areas, 1990.



Appendix A.4. Naknek-Kvichak District sockeye salmon catch, back-calculated in time to the North Peninsula Harbor Point to Cape Seniavin (upper panel) and Cape Seniavin to Strogonof Point (lower panel) areas, 1990.

Appendix B.1. North Peninsula systems estimated sockeye escapements, 1990.

System	Total Escapement	Percentage of Total
Nelson River	240,700	25.10
Bear River	546,800	57.03
Sandy River	21,875	2.28
Ilnik River	48,725	5.08
Meshik River	77,040	8.04
Cinder River	23,660	2.47
Total	958,800	

Appendix C.1. Description of scale measurement variables constructed using program REFORM1.

Description	Variable Name
Total Number of Circuli	V1
First Incrimental Distance (Focus to First Circulus)	V2
Second Incrimental Distance (Focus to Second Circulus)	V3
Third Incrimental Distance (Focus to Third Circulus)	V4
Forth Incrimental Distance (Focus to Fourth Circulus)	V5
Fifth Incrimental Distance (Focus to Fifth Circulus)	V6
Sixth Incrimental Distance (Focus to Sixth Circulus)	V7
Seventh Incrimenal Distance (Focus to Seventh Circulus)	V8
Eighth Incrimental Distance (Focus to Eighth Circulus)	V9
Ninth Incrimental Distance (Focus to Ninth Circulus)	V10
Tenth Incrimental Distance (Focus to Tenth Circulus)	V11
Eleventh Incrimental Distance (Focus to Eleventh Circulus)	V12
Twelfth Incrimental Distance (Focus to Twelfth Circulus)	V13